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Bose – Einstein Condensation an Super timidity

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Introduction

The oldest known physical manifestation of Bose condensation is super fluid 4He. A 4He. atom has total angular momentum zero an is therefore a boson. At Tc =k liquid helium becomes super fluid. The transition temperature is called γ point because the shape of the specific heat Sueur at Tc is shaped like. One cools liquid helium by pumping an it get rid of the hat atoms (evaporative cooing). It boils a little. There at the transition it boils vigorously and suddenly stops. The reason of this behavior is that the thermal conductivity increases by a factor of about 10^6 at the transition, so that the super fluid is no longer able to sustain a temperature gradient. To make a fluffed, heat has to locally vaporize the fluid and make it much hotter than the surrounding fluid. This is no longer possible in the super fluid. This is no longer possible in the super fluid state.

Perhaps the hallmark of a super fluid is that it has no viscosity. As a result the super fluid can flow through tiny capillary tubes that normal liquid can't get through. Super fluid 4 . He is often described by two – fluid model i.e., it is thought of as consisting of 2 fluids, one of which is normal and the other is super fluid. It's the super fluid component which is able to flow through the capillary tube. So if you use this method to measure the coefficient of viscosity, you find that it suddenly drops to zero at the γ -point.We mainly discuss three types of bubonic super fluids –

1. Super fluid with periodic density
2. Super fluid with periodic density
3. Super fluid of pure spin current

The focus is on the stability and critical velocities of various super fluids. For a uniform super fluid when its speed exudes a critical value, the system suffers Landau Insanity and super fluidity is lost. When the super fluid moves in a periodic potential, with large enough quasi – momentum, new mechanism of instability, usually dominates the Landau instability as it occurs on a much faster time scale. For a super fluid with spin orbit coupling, a dramatic is brought in, namely the breakdown of Galilean in variance. As a result, its critical velocity will depend on the reference frame. The stability of a pure spin current is also quite striking. We find that the pure spin current in general is not a super flow. However, it can be stabilized to become a super flow with quadratic Zeeman Effect or spin orbit coupling.

Basic concepts of super fluidity

I. Landau's theory of super fluidity –

The super fluidity of liquid 4He was first explained by L.D. Landau. He considered a super fluid moving inside a stationary tube with velocity 'V'. Since the system is invariant under the Galilean transformation, this scenario is equivalent to a stationary fluid inside a moving tube. If the elementary excitation in a stationery super fluid with momentum q has energy EO (q), then the energy of the same excitation in the back ground of a moving fluid with 'v' is $\varepsilon v\ (q) = \varepsilon o\ (q) + v.\ q$. A fluid experience Friction only through emitting elementary excitations and it is super fluid if these elementary excitations are energetically unfavorable. In other words, a super fluid satisfies the constraint $\varepsilon o\ (q) > o$. It readily leads to will know Landau's criterion for super fluidity,

$$U < V_c = \left(\frac{\varepsilon o(q)}{|q|} \right)$$

Here $V_C$is the critical velocity of the super fluid, which is determined by the smallest shop of the excitation spectrum of a stationary superfluid. The remark is warranted on Landau's theory of superfluidity. Landau's criteria (1) of critical speed do not apply for many superfluids. However Landau's energetic argument for superfluidity is very general and can be applied to all the cases considered in this review. We shall use this argument to determine the critical speeds of various superfluids.
Types of Bosonic superfluids –

[A] Periodic Superfluid

It is her to change the enmity of Helium 4 as it is a liquid. In contrast, we can easily modulate the density of B.E.C which is a gas. When we put a BEC in an optical lattice, we obtain a superfluid. Whose density is periodically modulated? One can even further periodically modulate the interatomic interaction of the BEC with optical Feshbach resonance. Super solid helium 4 may be also regarded as a periodic superfluid as it can be vie used as some superfluid defeats (most likely vacancies) flowingin a helium solid lattice. Here, we use use a BEC in an optical lattice as an example to examine the properties of a periodic superfluid. Compare to the uniform superfluid in free space, a new type of instability i.e. the dynamical instability is found when the quasi – momentum of the superfluid is larger than a critical value usually the dynamical instability dominates the accompanying landau instability as it happens on a much faster time scale. The presence of the periodic potential also brings along another critical velocity

[B] Superfulidity with spin orbit coupling

The intrinsic spin orbit coupling (soc) of electrons plays a crucial soul in many exotic materials, such as topological insulators. In spintronics, its presence enables us to manipulate the spin of electrons by means of exerting electric field instead of magnetic field, which is much easier to implement for industrial applications. However, as a relativistic effect, the intrinsic soc does not exist or is weak for bosons in nature. With the method of engineering atom. Laser interaction, an artificial soc has been realised for ultra cold bubonic gases. A great deal of effort has been devoted to study many interesting properties of spin orbit coupled BEC's.

A dramatic change that the soc brings to the concept of superfluidity is the breakdown of Landau's criterion of critical velocity
(1) and the appearance of two different critical velocities. In experiments of ultra – cold atomic gases, the soc is created by two Ramah Galilan transformation only boosts the BEC, not including the

loser setup as a whole, the moving BEC will experience a different laser field due to Doppler effect, resulting a loss of the Galilean invariance.

[C] [C]

Superfluidity of spin current

A neutral boson can carry both mass and spin; it thus can both mass current and spin current. However when a boson system is said to be superfluid, it traditionally refers only to its mass current. For a boson with spin, say, a spin – 1 boson, we can in fact have a pure spin current, a spin current with no mass current. This pure spin current can be generated by putting an unpolarised spin-1 boson system in a magnetic field with a small gradient.
The pure spin current in an impolarised spin-1 Bose gas is generally unstable and is not a superflow. The pure spin flow can be stabilized to become superflow –

1. For a planer flow, it can be stabilized by quadratic Zeeman effect
2. For a circular flow, it can be stabilized with soc

The counter flow in a two species BEC is not a pure spin current for two reasons –

i. Although the two species may be regarded as two components of pseudo – spin ½, they do not have Su Symmetry.
ii. It is hard to prepare experimentally a BEC with exactly equal numbers of bosons in the two species to create a counter flow with no mass current.

In summary, we have studied the superfluidity of three kinds of unconventional superfluids, which show distinct features from a spineless superfluid. With the rapid advancements in cold atom physics and other fields, the family of superfluids is expanding with edition of more and more novel superfluids.

References –

1. P. Kapitsa, Nature 141, 74 (1938)
2. J.F. Allen and Ad. Misever, Nature 141, 75 (1938) 3.

T.L. Ho, Phys, Rev. Letl. 81, 742 (1998)

4. A. Griesmaier etal. Phys. Rev. Lett. 94, 160401 (2005)
5. F. London, superfluids Vol. 11 (Dover, 1954)

6. P.Nozieres and D. Pines, The theory of puncture liquids vol. 11 (Addison – wosley, 1990)

7. J. Kaspraak et al., Nature 443, 409 (2006)

8. A. Aneo et al. Nat, Phys. 5, 805 (2000)

9. M.J. Edmonds et al. New J. Phys. 14, 073056 (2012)

10.Lychkovskiy o 2014 phys. Rev. A 89 0 33619 11.Landou L D
1941 j. Phys. UssR 571

12. Casey K F, yeh c and kaprietion, Z A 1965 Phy. Rev. 140B768

13. C. Raman etal. Phys, Rev Lett. 83, 2502 (1999)

14.C.J Pethick and r1 smith, Bose Einstein condensation in dilute Gases, second edition, combridge university press, 2002

15.L. Fallow et al. Phys, Rev. Letl. 93, 140406 (2004)

16.B. wu and P. Niu, Phys. Rev .A 64, O61603 (R) (2001)